US009383455B2

(12) **United States Patent**
Makino et al.

(10) **Patent No.: US 9,383,455 B2**
(45) **Date of Patent: Jul. 5, 2016**

(54) **RADIATION MEASUREMENT APPARATUS**

(71) Applicant: **KABUSHIKI KAISHA TOSHIBA**, Minato-Ku (JP)

(72) Inventors: **Shunichiro Makino**, Yokosuka (JP); **Toru Onodera**, Yokohama (JP); **Yoshinori Satoh**, Yokohama (JP); **Naoto Kume**, Yokohama (JP)

(73) Assignee: **KABUSHIKI KAISHA TOSHIBA**, Minato-ku (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 141 days.

(21) Appl. No.: **14/348,393**

(22) PCT Filed: **Sep. 28, 2012**

(86) PCT No.: **PCT/JP2012/075221**
§ 371 (c)(1),
(2) Date: **Mar. 28, 2014**

(87) PCT Pub. No.: **WO2013/047824**
PCT Pub. Date: **Apr. 4, 2013**

(65) **Prior Publication Data**

US 2014/0231646 A1 Aug. 21, 2014

(30) **Foreign Application Priority Data**

Sep. 30, 2011 (JP) 2011-217997

(51) **Int. Cl.**
G01T 1/17 (2006.01)
G01T 1/172 (2006.01)

(52) **U.S. Cl.**
CPC ***G01T 1/172*** (2013.01); ***G01T 1/171*** (2013.01)

(58) **Field of Classification Search**
CPC G01T 1/02; G01T 1/04; G01T 1/023; G01T 1/026; G01T 1/17; G01T 1/171; G01T 1/178; G01T 1/172
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,924,106 A * 12/1975 Keefe G01T 1/178 377/19

(Continued)

FOREIGN PATENT DOCUMENTS

JP	4 36682	2/1992
JP	2004 529367	9/2004

OTHER PUBLICATIONS

Office Action issued Jul. 14, 2015 in Japanese Patent Application No. 2011-217997.
International Preliminary Report on Patentability issued Apr. 10, 2014 in PCT/JP2012/075221 filed on Sep. 28, 2012 (English translation only).

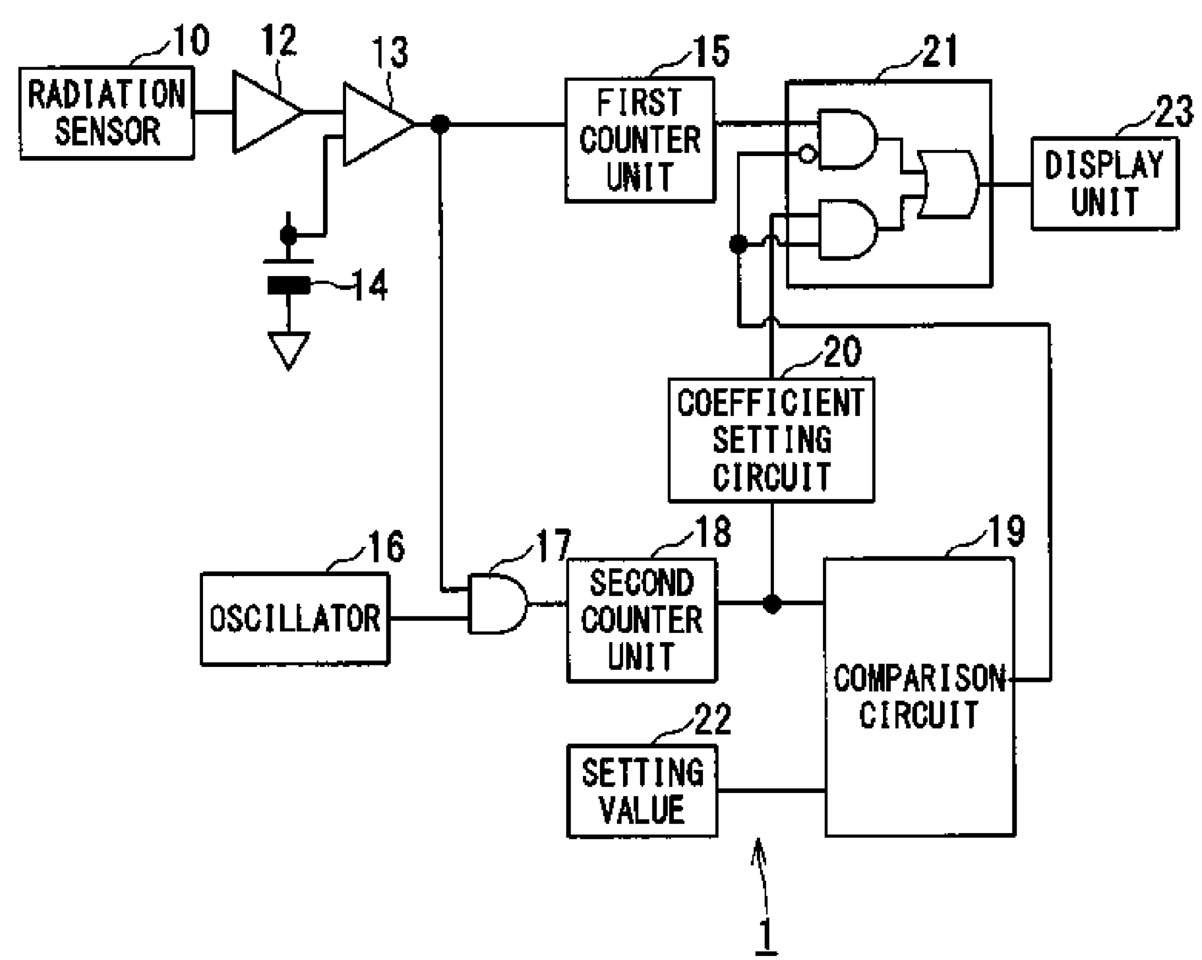
(Continued)

Primary Examiner — Casey Bryant
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A radiation measurement apparatus includes a radiation sensor that generates a detection signal, a first counter unit that counts the number of the detection signal, an oscillator that generates periodic signal with predetermined period, an AND circuit that outputs logical product obtained by performing AND operation between the detection signal and the periodic signal, a second counter unit that counts the number of a signal output from the AND circuit, and a display unit that displays a value counted by the first counter unit when a value counted by the second counter unit is less than predetermined value and a value being different from the value counted by the first counter unit when the value counted by the second counter unit is not less than predetermined value.

11 Claims, 5 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,485,442	A *	11/1984	Snaper	G01T 1/17	250/336.1
6,609,075	B1 *	8/2003	Warburton	G01T 1/17	702/22
2006/0276706	A1 *	12/2006	Klein	G01T 1/171	600/407

OTHER PUBLICATIONS

Written Opinion issued Oct. 23, 2012 in PCT/JP2012/075221 filed on Sep. 28, 2012 (English translation only).

International Search Report Issued Oct. 23, 2012 in PCT/JP12/075221 Filed Sep. 28, 2012.

* cited by examiner

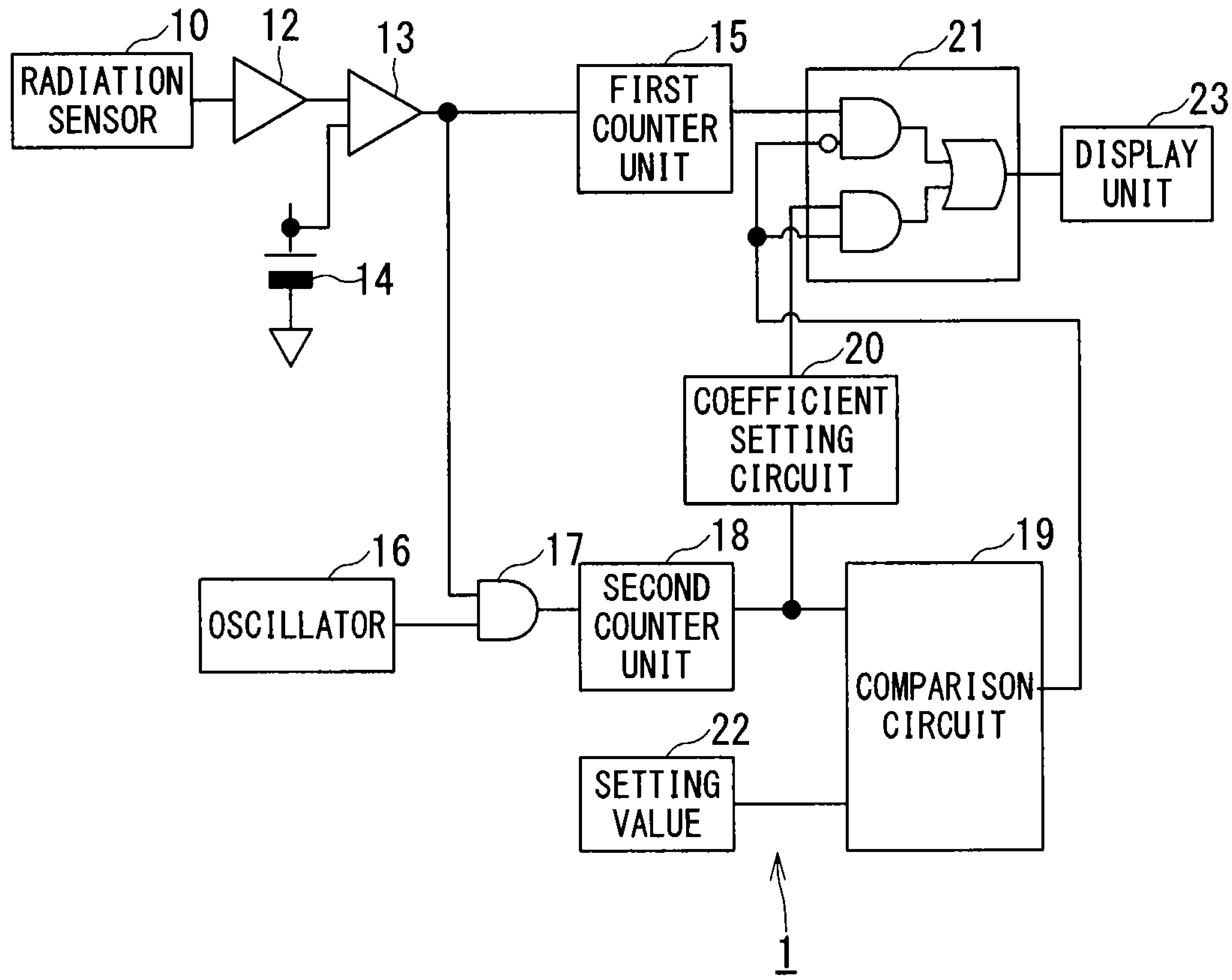


FIG. 1

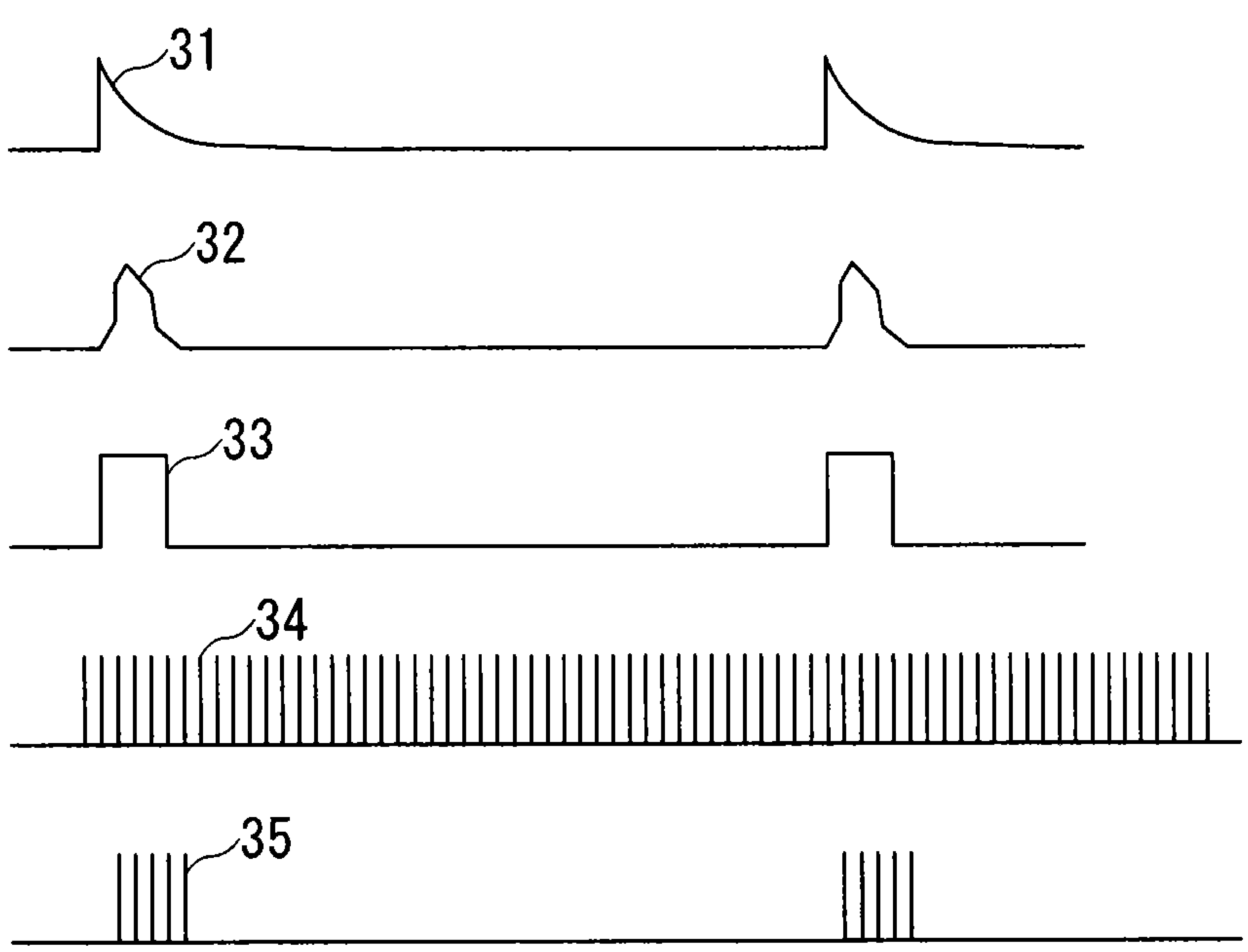


FIG. 2A
FIG. 2B
FIG. 2C
FIG. 2D
FIG. 2E

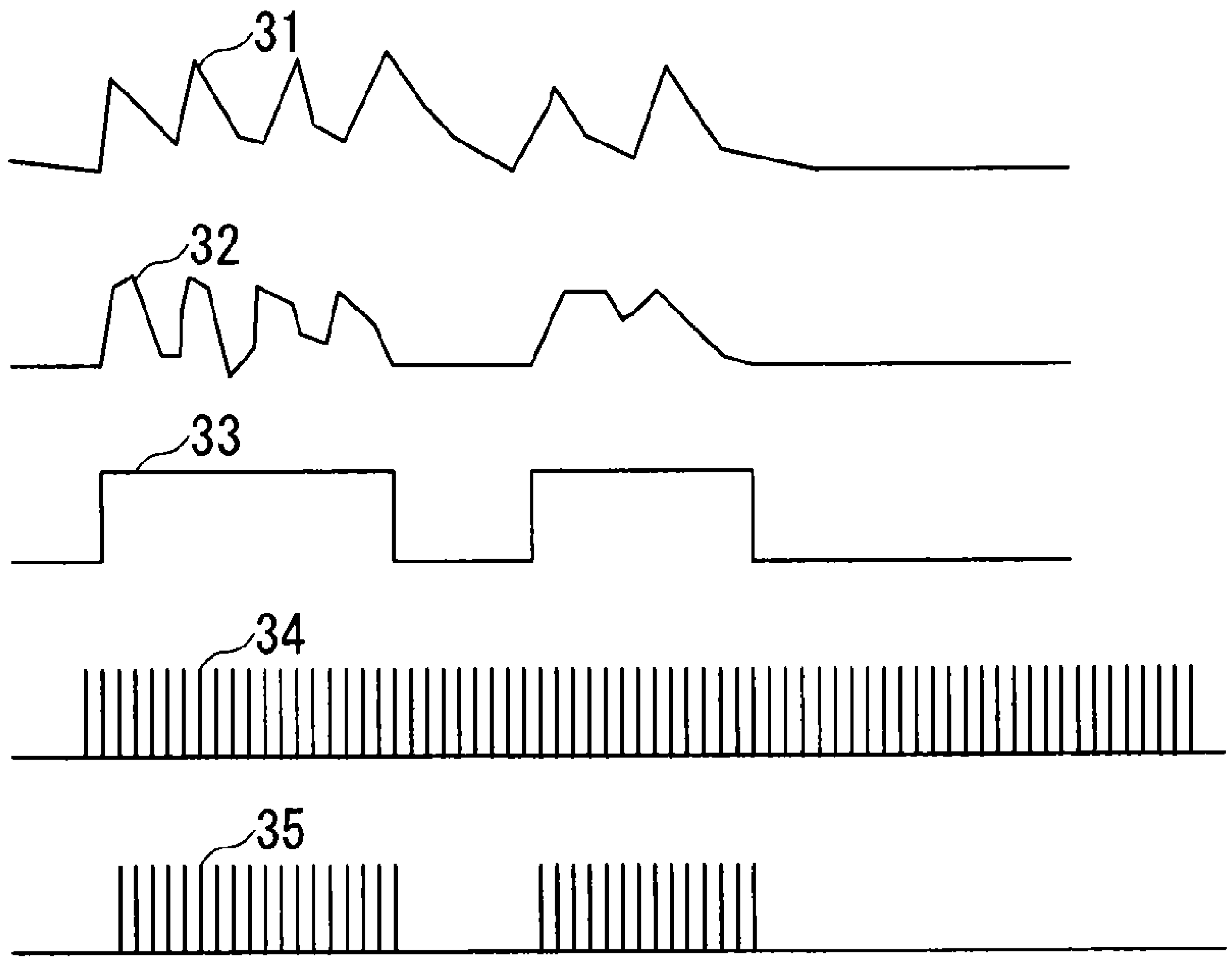


FIG. 3A
FIG. 3B
FIG. 3C
FIG. 3D
FIG. 3E

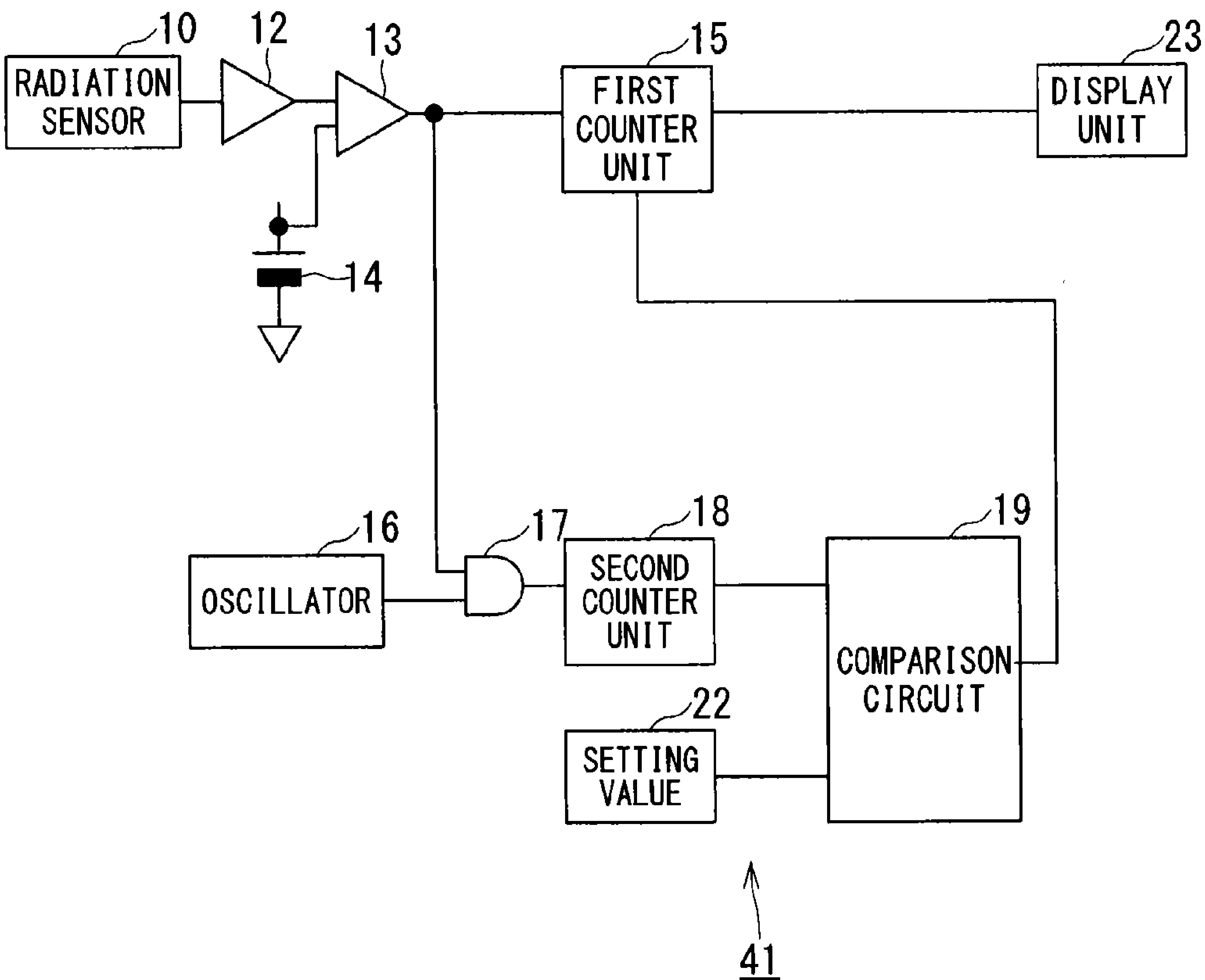


FIG. 4

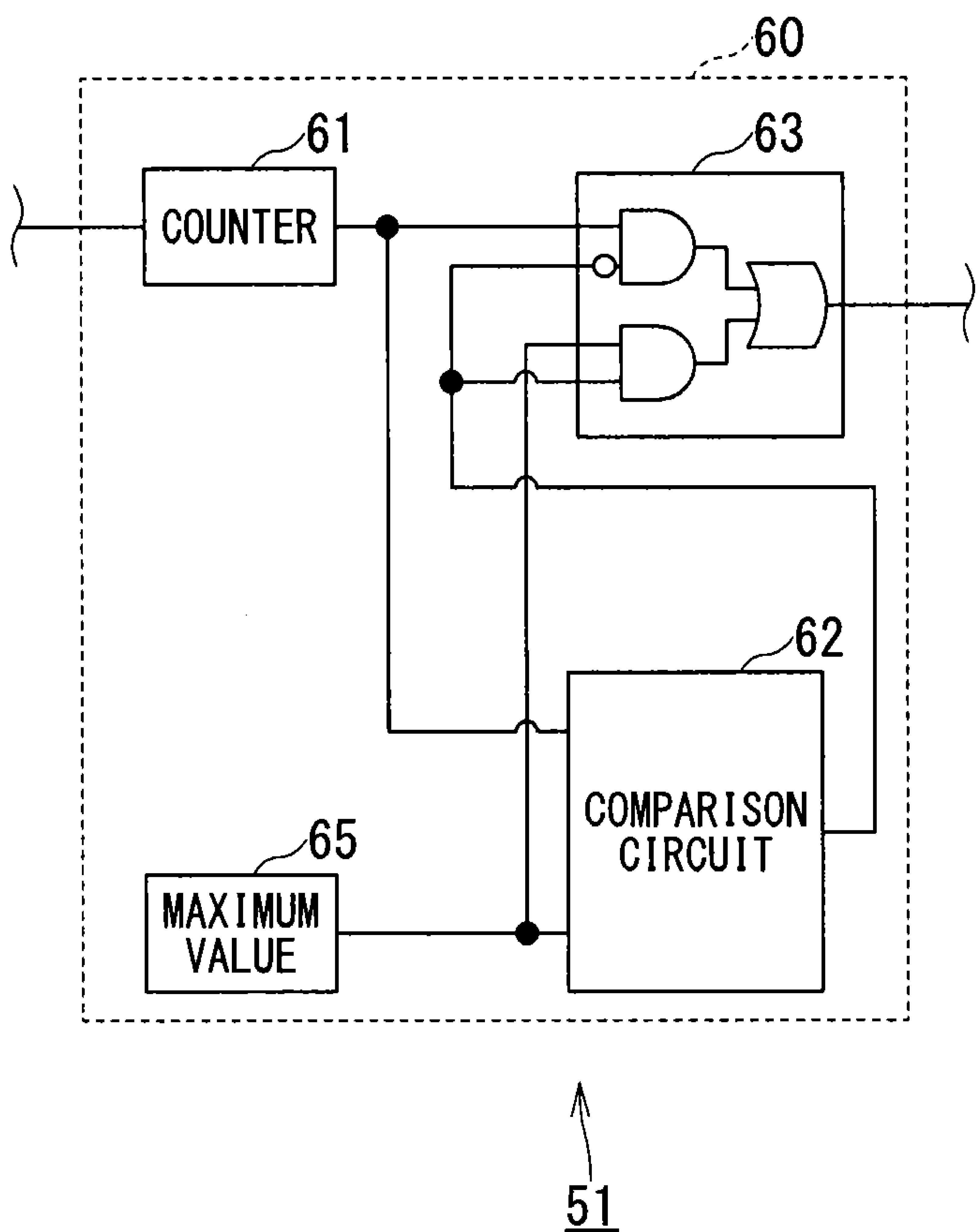


FIG. 5

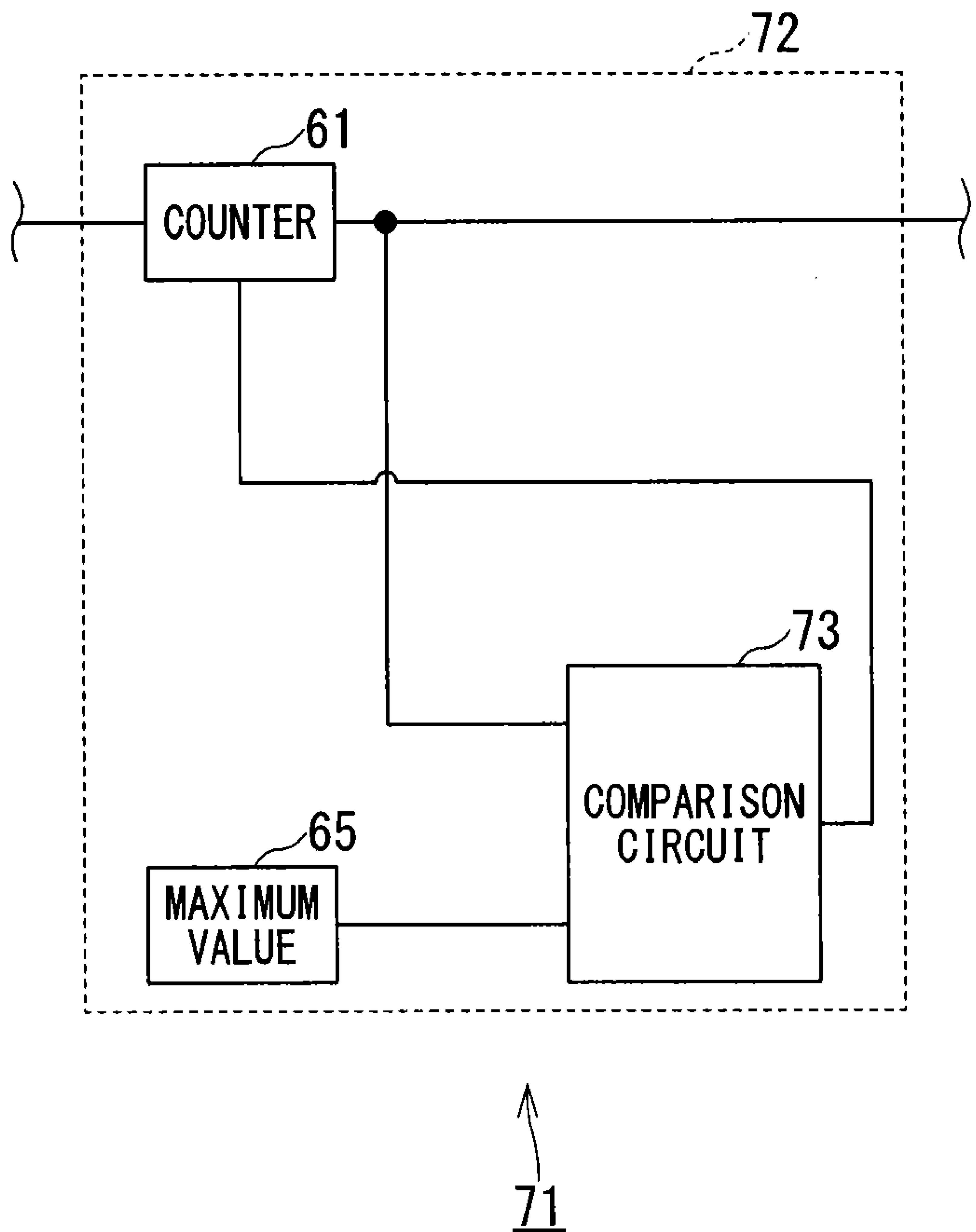


FIG. 6

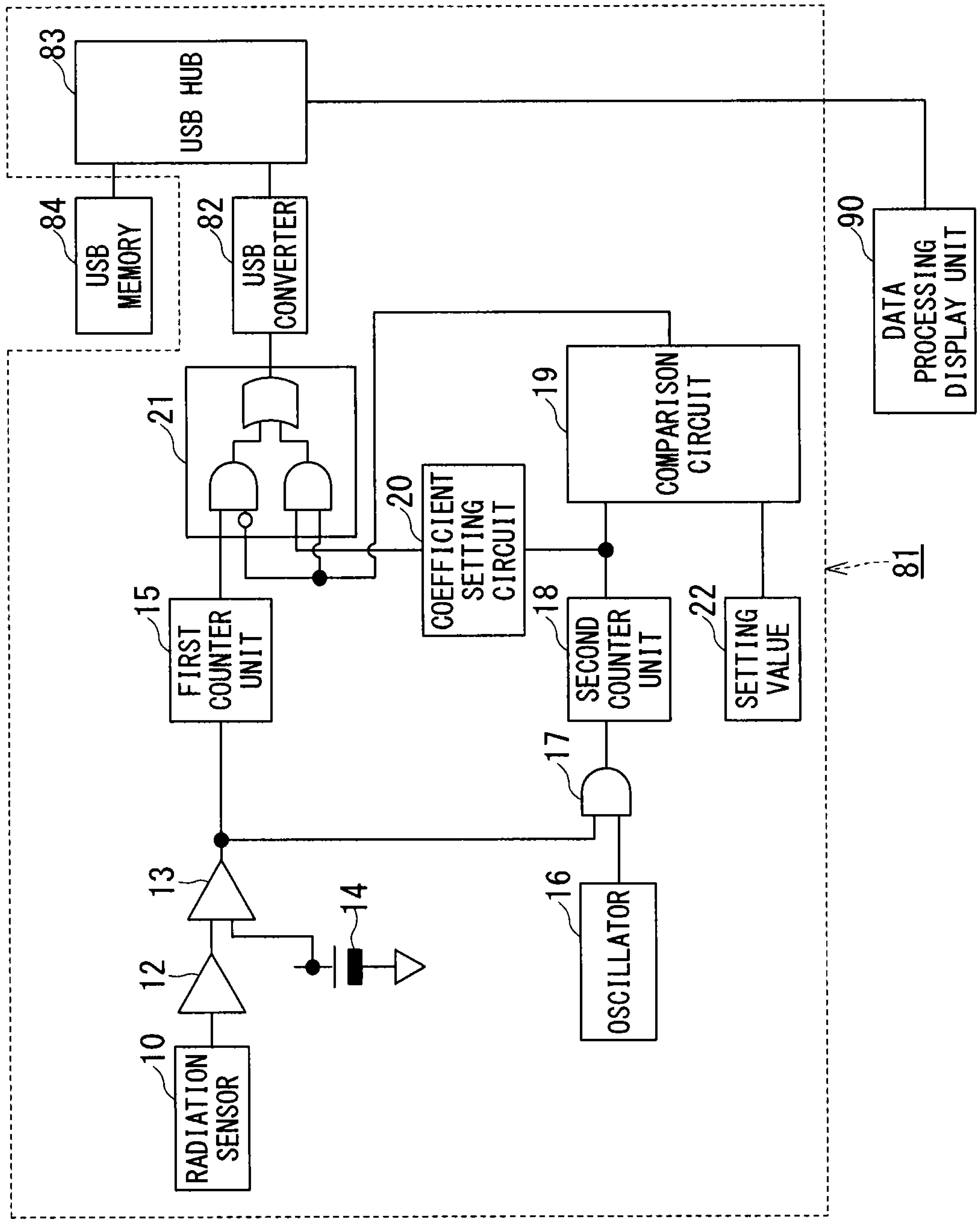

83
USB HUB
84
USB MEMORY
82
USB CONVERTER
90
DATA PROCESSING DISPLAY UNIT
21
19
COMPARISON CIRCUIT
20
COEFFICIENT SETTING CIRCUIT
15
FIRST COUNTER UNIT
18
SECOND COUNTER UNIT
22
SETTING VALUE
81
17
13
14
12
16
OSCILLATOR
10
RADIATION SENSOR

FIG. 7

RADIATION MEASUREMENT APPARATUS

TECHNICAL FIELD

The present invention relates to an apparatus that detects and counts radiation.

BACKGROUND ART

In a facility which treats radiation material, such as nuclear power plant or the like, in a case where an accident occurs, there is a possibility which flies (scatters) a radiation material having strong radioactivity over a wide range. Accordingly, it occurs to need to widely research whether the radiation material is present or not. Thus, a result of the research, if the radiation material is present, it is necessary to remove the radiation material.

Many human resources are necessary for a measurement whether radiation material is present or not. Accordingly, the worker having a little knowledge and skill may need to measure whether radiation material is present or not. In this case, some objects may occur as follows.

If radiation is detected in the radiation measurement apparatus, electric pulse is generated. The generated pulse is counted by a latter counting circuit. In a case where radioactivity is strong, the number of the radiation becomes large number. Since an interval between electric pulses narrows, the radiation measurement apparatus becomes a state (which will be hereinafter referred to as "pile-up") where the electric pulses overlap each other.

If the pile-up is occurred in the radiation measurement apparatus, since a plurality of the pulses which overlaps each other are considered as single (one) pulse, in fact, a value (which will be hereinafter referred to as "count value") counted by the counting circuit becomes smaller than actual radiation number detected by the radiation measurement apparatus. Further, in a case where the pile-up occurs by overlapping all electric pulses, the count value becomes zero (0). Thus, even though there is the radiation material having strong radioactivity in fact, there is a possibility being determined that here radioactivity is weak. In case of being determined that here radioactivity is weak, because the radiation material is not eliminated, a risk led to radiation exposure may be occurred.

Conventionally, a technique for detecting pile-up and a technique for preventing from pile-up are proposed (for example, refer to patent documents 1 and 2).

Further, if a count number of the counting circuit within measurement time exceeds over a measurement capacity of the counting circuit, because it occurs digit overflow (which will be hereinafter referred to as "overflow"), the count number output from the counting circuit becomes less than the count number input to the counting circuit. For example, in a case where an 8 bit counting circuit is used, maximum count value (measurement capacity) is 255. Accordingly, if the count value of the counting circuit reaches 256 within measurement time, the count value returns from 255 to 0. In above-described case, as same case as pile-up, it may be wrongly determined that a radioactivity is weak. Accordingly, the wrong determination is caused a risk led to radiation exposure.

Conventionally, for the sake of avoiding fault-measurement caused by the overflow, in the event that the counting circuit is overflowed, a technique for displaying contents that the counting circuit is overflowed is proposed (refer to non-patent document 1).

PRIOR ART DOCUMENT

Patent Document

Patent Document 1: Publication of (Unexamined) Patent Application No. Heisei 07-072252

Patent Document 2: Publication of (Unexamined) Patent Application No. 2009-18154

Non-Patent Document

Non-Patent Document 1: http://www.clearpulse.co.jp/jpn/product/plist_E/plistE1.html

DESCRIPTION OF INVENTION

Problems to be Solved by Invention

Although conventional technique can detect pile-up and prevent from occurring pile-up, conventional technique leads apparatus to be complicated and enlarged. Further, although the radiation measurement apparatus displays over-flow occurrence in case of occurring over-flow, count display in the radiation measurement apparatus over-flows. Therefore, it is difficult for an operator that is not familiar with treatment of the radiation measurement apparatus for an operator to determine whether the overflow is occurred.

The present invention has been made in consideration of the circumstances mentioned above, and an object thereof is to provide a radiation measurement apparatus which can prevent from wrong determination of radiation without depending on or knowledge, as to the radiation measurement of the operator.

Means for Solving Problem

In order to solve the problem in the conventional art mentioned above, the present invention provides a radiation measurement apparatus including: a sensor that generates a detection signal in case of detecting a radiation; a first counter that counts the number of the detection signal; an oscillator that generates a periodic signal with predetermined period; an AND circuit that outputs logical product obtained by operating AND operation between the detection signal and the periodic signal; a second counter that counts the number of a signal output from the AND circuit; and a display unit that displays a count value of the first counter in a case where a count value of the second counter is less than a first predetermined value and a value which is different from the count value of the first counter in a case where the count value of the second counter is not less than the first predetermined value.

Effect of Invention

A radiation measurement apparatus according to the present invention can prevent an operator from faultily recognizing radioactivity without depending on skill and knowledge level, regarding radiation measurement, of the operator.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a circuit configuration diagram of a radiation measurement apparatus according to first embodiment.

FIG. **2** (which includes FIGS. **2**A to **2**E) is an explanation view illustrating an aspect of a pulse generated in a comparator, an oscillator, and an AND circuit, in the event that a pile-up is not generated. Here, FIG. **2**A is a view illustrating an electric pulse output from a radiation sensor, FIG. **2**B is a view illustrating a shaped pulse shaped by a wave shaping circuit and then output from the wave shaping circuit, FIG. **2**C is a view illustrating detection pulse output from the comparator, FIG. **2**D is a view illustrating periodic pulse output from the oscillator, and FIG. **2**E is a view illustrating an output signal output from the AND circuit.

FIG. **3** (which includes FIGS. **3**A to **3**E) is an explanation view illustrating an aspect of a pulse generated in a comparator, an oscillator, and an AND circuit, in the event that a pile-up is generated. Here, FIG. **3**A is a view illustrating an electric pulse output from a radiation sensor, FIG. **3**B is a view illustrating formed pulse formed and output from, FIG. **3**C is a view illustrating detection pulse output from the comparator, FIG. **3**D is a view illustrating periodic pulse output from the oscillator, and FIG. **3**E is a view illustrating an output signal output from the AND circuit.

FIG. **4** is a circuit configuration diagram of a radiation measurement apparatus as another example of the first embodiment.

FIG. **5** is a circuit configuration diagram of a first counter unit of a radiation measurement apparatus according to second embodiment.

FIG. **6** is a circuit configuration diagram of a radiation measurement apparatus as another example of the second embodiment.

FIG. **7** is a circuit configuration diagram of a radiation measurement apparatus according to third embodiment.

EMBODIMENT FOR CARRYING OUT THE INVENTION

First Embodiment

A first embodiment of a radiation measurement apparatus according to the present invention will be described with reference to the accompanying drawings.

FIG. **1** is a circuit configuration diagram of a radiation measurement apparatus **1** according to the first embodiment.

The radiation measurement apparatus **1** includes a radiation sensor **10**, a waveform shaping circuit **12**, a comparator **13**, a discrimination level setting unit **14**, and a first counter unit **15**, as a radiation measurement device.

When the radiation sensor **10** detects radiation, the radiation sensor **10** generates electric pulse. The waveform shaping circuit **12** converts the electric pulse into a pulse which can be counted by latter circuit. The comparator **13** discriminates the converted pulse output from the waveform shaping circuit **12**. The discrimination level setting unit **14** outputs setting voltage as discrimination level in the discrimination level setting unit **14** to the comparator **13**. The first counter unit **15** counts the number of detection pulses as an output of the comparator **13** for a predetermined length of time.

The radiation measurement apparatus **1** includes an oscillator **16**, an AND circuit **17**, a second counter unit **18**, a comparison circuit **19**, a coefficient setting circuit **20** and a selector **21**, as a pile-up prevention device that prevents pile-up.

The oscillator **16** continuously generates periodic pulse (periodic signal) with predetermined period. The AND circuit **17** outputs logical product obtained by performing AND operation between the detection pulse output from the comparator **13** and the periodic pulse output from the oscillator **16**. The second counter unit **18** counts the number of signal output from the AND circuit **17** for predetermined length of time. The comparison circuit **19** outputs a logic signal which is "true" in a case where a value output from the second counter unit **18** is equal or more (not less) than a setting value **22** and a logic signal which is "false" in a case where a value of the second counter unit **18** is less than the setting value **22**. The coefficient setting circuit **20** sets predetermined coefficient which is multiplied by the value output from the second counter unit **18**. In a case where the output from the comparison circuit **19** is false, the selector **21** (display control circuit) outputs a count value of the first counter unit **15**. Further, in a case where the output from the comparison circuit **19** is true, the selector **21** outputs a value obtained by multiplying the count value of the second counter unit **18** by a coefficient.

Further, the radiation measurement apparatus **1** includes a display unit **23** which displays the output value of the first counter unit **15** and the output value of the second counter unit **18**. The output values are output from the selector **21**.

Next, an operation of the radiation measurement apparatus **1** according to the first embodiment will be described.

FIG. **2** (which includes FIG. **2**A to **2**E) is an explanation view illustrating an aspect of a pulse generated in the comparator **13**, the oscillator **16** and the AND circuit **17**, in the event that a pile-up is not generated. FIG. **2**A is an explanation view illustrating electric pulses **31** output from the radiation sensor **10**, FIG. **2**B is an explanation view illustrating shaped pluses **32** shaped by the waveform shaping circuit **12** and then output from the waveform shaping circuit **12**, FIG. **2**C is an explanation view illustrating detection pulses **33** output from the comparator **13**, FIG. **2**D is an explanation view illustrating periodic pulses **34** output from the oscillator **16**, and FIG. **2**E is an explanation view illustrating the output signal **35** output from the AND circuit **17**.

If the radiation sensor **10** detects radiation, as illustrated in FIG. **2**A, the electric pulse **31** is generated. The waveform shaping circuit **12** shapes the electric pulse **31** into the shaped pulse **32** of which width is several micro-seconds (μs), illustrated in FIG. **2**B. In a case where a wave height value of the shaped pulse **32** is larger than a voltage set in the discrimination level setting unit **14**, the comparator **13** outputs the detection pulse (detection signal) **33** that represents 1 (High level), illustrated in FIG. **2**C. Since the width of the shaped pulse **32** is several μs, the detection pulse **33** as an output of the comparator **13** becomes pulse of which width is several μs. The output of the comparator **13** is output to the first counter unit **15**. The first counter unit **15** counts the detection pulse **33** for the predetermined length of time.

The detection pulse **33** is simultaneously output to the AND circuit **17**. The AND circuit **17** calculates logical product between the detection pulse **33** output from the comparator **13** and the periodic pulse **34** output from the oscillator **16**. That is, the AND circuit **17** outputs the periodic pulse **34** output from the oscillator **16** as output signal **35** to the second counter unit **18** while the comparator **13** outputs 1 (High level) signal (while the detection pulse **33** is output). The second counter unit **18** counts an output of the AND circuit **17** for a predetermined length of time. The width of the periodic pulse **34** is adequately small and, for instance, about one-fifth of the width of the detection pulse **33**. It is set so as to always output the periodic pulse **34** to the second counter unit **18** while the shaped pulse **32** is generated.

The comparison circuit **19** compares the value counted by the second counter unit **18** with the setting value **22**. The setting value **22** is arbitrarily selected a value which can be determined whether the radiation measurement apparatus **1** becomes pile-up state or not, and set. The comparison circuit **19** outputs a logic signal which is false in a case where the value of the second counter unit **18** is less than the setting value **22**, i.e., in a case where the radiation measurement apparatus **1** does not become pile-up state but the count value of the output signal **35** is small.

If the output of the comparison circuit **19** is false, the selector **21** outputs the output value of the first counter unit **15** to the display unit **23**. The display unit **23** displays actual count value which corresponds to the entering number of the radiation.

Herein, FIG. **3** (which includes FIGS. **3**A to **3**E) is explanation view illustrating an aspect of a pulse generated in the comparator **13**, the oscillator **16**, and the AND circuit **17**, in the event that a pile-up is generated.

As illustrated in FIG. **3**A, in a case where the count number of the electrical pulse **31** in the radiation sensor **10** is large number, as illustrated in FIG. **3**B, the radiation measurement apparatus **1** becomes the pile-up state thereby overlapping the shaped pulses **32**. As a result of becoming the pile-up state, as illustrated in FIG. **3**C, since the detection pulses **33** of the comparator **13** also overlaps, the detection pulses **33** overlapped each other broadens pulse width thereof. Thus, even though radiation is strong, since the number of the detection pulses **33** decreases, the count value counted by the first counter unit **15** for the predetermined length of time becomes small.

The AND circuit **17** outputs the periodic pulse **34** output from the oscillator **16** as output signal **35** to the second counter unit **18** while the comparator **13** outputs 1 (High level) signal (while the detection pulse **33** is output). That is, although the count value of the first counter unit **15** decreases, the output signal **35** increases in proportion to width of the detection pulse **33**. Therefore, the count value of the second counter unit **18** increases.

The comparison circuit **19** compares the value counted by the second counter unit **18** with the setting value **22**. The comparison circuit **19** outputs a logic signal which is true in a case where the value of the second counter unit **18** is equal and more than the setting value **22**, i.e., in a case where the count value of the output signal **35** is large by becoming pile-up state.

If the output of the comparison circuit **19** is true, the coefficient setting circuit **20**. The selector **21** outputs a calculation value (which is based on the count value of the second counter unit **18**) of the coefficient setting circuit **20** which multiplies the value output from the second counter unit **18** by the coefficient to the display unit **23**. The display unit **23** reflects a actual radiation count value and then displays the value. That is, the radiation sensor **10** becomes pile-up state and the output from the first counter unit **15** of which count value becomes small is not displayed. Incidentally, the coefficient setting circuit **20** is included in the radiation sensor **10** so that output value becomes successive value in case of switching between the count value of the first counter unit **15** and the output value of the second counter unit **18**, and arbitrarily sets the coefficient thereof.

The radiation measurement apparatus **1** in first embodiment detects whether the shaped pulse **32** becomes the pile-up state based on the count value of the second counter unit **18**. When the pile-up state of the shaped pulse **32** is detected, the radiation measurement apparatus **1** switches from the count value of the first counter unit **15** to the output value of the second counter unit **18**. As a result, the count value displayed in the display unit **23** does not become smaller and becomes large value which reflects a state in real radioactivity. Thus, the radiation measurement apparatus **1** can prevent the operator from faultily recognizing radioactivity without depending on skill and knowledge level, regarding radiation measurement, of the operator.

Incidentally, in a case where the count value of the second counter unit **18** is larger than the setting value **22**, the radiation measurement apparatus **1** according to first embodiment may be configured so as to set predetermined value differing from actual count value (present count value) of the first counter unit **15** in the first counter unit **15**, and thereby display the value set in the first counter unit **15** as count value in the display unit **23**.

FIG. **4** is a circuit configuration diagram of a radiation measurement apparatus **41** according to another example of the first embodiment. Incidentally, it is noted that the same reference numerals or characters in the radiation measurement apparatus **41** are assigned to the same or similar components and parts as those in the radiation measurement apparatus **1**, and the duplicated description thereof is omitted (not described).

The radiation measurement apparatus **41** includes the radiation sensor **10**, the shaping circuit **12**, the comparator **13**, the discrimination level setting unit **14**, and the first counter unit **15**, as the radiation measurement device. Further, the radiation measurement apparatus **41** includes the oscillator **16**, the AND circuit **17**, the second counter unit **18**, and the comparison circuit **42**, as the pile-up prevention device that prevents the pile-up. Furthermore, the radiation measurement apparatus **41** includes the display unit **23**.

The comparison circuit **42** outputs the logical signal which is true in the event that the value of the second counter unit **18** is equal and larger than the setting value **22** and the logical signal which is false in the event that the value of the second counter unit **18** is less than the setting value **22**. In the first counter unit **15**, a predetermined value is set as setting value in a case where an output of the comparison circuit **42** is the true logical signal.

An operation of the radiation measurement apparatus **41** as another example will be explained.

The comparison circuit **42** compares the count value of the second counter unit **18** with the setting value **22**. In a case where the count value of the second counter unit **18** is less than the setting value **22**, that is, in case of not being pile-up state, since the comparison circuit **42** outputs a logic signal which is false, the first counter unit **15** outputs actual count value to the display unit **23**. The display unit **23** displays a count value corresponding to a detection number of radiation.

In a case where the count value of the second counter unit **18** becomes equal and more than the setting value **22**, that is, in case of becoming the pile-up state, the comparison circuit **42** outputs a logic signal which is true. The comparison circuit **42** outputs the true logic signal and therefore subjects the first counter unit **15** to output value preliminarily set as the count value. The preliminarily set value is, for example, a maximum value of the first counter unit **15**. The maximum value is larger than a count value after the count value of the first counter unit **15** is reduced by occurring pile-up. The count value of the first counter unit **15**, being set by the comparison circuit **42** is output to the display unit **23** and displayed in the display unit **23**.

In the radiation measurement apparatus **41**, because the count value of the first counter unit **15** is preset as large value, even if the pile-up state is detected, the count value displayed in the display unit **23** does not become smaller. The radiation measurement apparatus **41** displays large value, and is therefore possible to prevent the operator from faultily recognizing radioactivity without depending on skill and knowledge level, regarding radiation measurement, of the operator.

Further, as the radiation measurement apparatus **41** may omit the selector **21** which is included in the radiation measurement apparatus **1**, a configuration of the radiation measurement apparatus **41** may be simplified.

Second Embodiment

A second embodiment of a radiation measurement apparatus according to the present invention will be described with reference to the accompanying drawings.

FIG. **5** is a circuit configuration diagram of a first counter unit **60** of a radiation measurement apparatus **51** according to second embodiment.

The different point between the radiation measurement apparatus **51** according to the second embodiment and the radiation measurement apparatus in the first embodiment is that the first counter unit **60** includes a component for preventing an operator from wrong determination caused by overflow of the first counter unit **60**. In the radiation measurement apparatus **51**, a component other than the first counter unit **60** is substantially as the same component of the radiation measurement apparatus **1** according to the first embodiment, and is omitted (not illustrated) in FIG. **5**. Further, it is noted that the same reference numerals or characters in the radiation measurement apparatus **51** are assigned to the same or similar components and parts as those in the radiation measurement apparatus **1**, and the duplicated description thereof is omitted.

The radiation measurement apparatus **51** includes the radiation sensor **10**, the shaping circuit **12**, the comparator **13**, the discrimination level setting unit **14** (please refer to FIG. **1**), and the first counter unit **60**. Further, the radiation measurement apparatus **51** includes the oscillator **16**, the AND circuit **17**, the second counter unit **18**, and the comparison circuit **19** (please refer to FIG. **1**), as the pile-up prevention device that prevents the pile-up. Namely, the radiation measurement apparatus **51** may omit (not include) the pile-up prevention device.

The first counter unit **60** includes a counter **61**, a comparison circuit **62**, and a selector **63**, as the pile-up prevention device that prevents pile-up.

The counter **61** counts the number of signal output from the comparator **13** for predetermined length of time. The comparison circuit **62** outputs a logic signal which is true in a case where a count value of the counter **61** reaches a maximum value **65** and a logic signal which is false in a case where the count value of the counter **61** is less than (does not reach) the maximum value **65**. In a case where the comparison circuit **62** outputs the logical signal which is false, the selector **63** outputs actual count value of the counter **61**. Further, in a case where the comparison circuit **62** outputs the logical signal which is true, the selector **63** outputs the maximum value **65** of the counter **61**.

Next, an operation of the radiation measurement apparatus **51** according to the second embodiment will be explained.

If the radiation sensor **10** detects radiation, the electric pulse **31** is generated. The waveform shaping circuit **12** shapes the electric pulse **31** into the shaped pulse **32** of which width is several micro-seconds (μs). In a case where a wave height value of the shaped pulse **32** is larger than a voltage set in the discrimination level setting unit **14**, the comparator **13** outputs the detection pulse (detection signal) **33** that represents 1 (High level). Since the width of the shaped pulse **32** is several μs, the detection pulse **33** as an output of the comparator **13** becomes pulse of which width is several μs. The output of the comparator **13** is output to the counter **61** of the first counter unit **60**. The counter **61** counts the detection pulse **33** for the predetermined length of time.

The comparison circuit **62** compares the count value of the counter **61** with the maximum value **65**. If the count value of the counter **61** is less than the maximum value **65**, the comparison circuit **62** outputs a logic signal which is false. The selector **63** outputs actual count value of the counter **61** the maximum value **65** to the display unit **23**. The display unit **23** displays the count value of the counter **61**.

Meanwhile, there is a case where the count value of the counter **61** becomes the maximum value **65**, that is, the count value of the counter **61** reaches a measurable maximum value. In this case, the comparison circuit **62** outputs a logic signal which is true. Thus, the selector **63** outputs the maximum value **65** of the counter **61** to the display unit **23** until a predetermined timing (for example, next measurement is started). The display unit **23** displays the maximum value **65** of the counter **61**.

As a result of procedure described above, the counter value of the counter **61** does not become smaller than the maximum value **65** by occurring overflow, and is held.

In the radiation measurement apparatus **51** according to the second embodiment, the first counter unit **60** (the counter **61**) detects whether the count value thereof reaches the maximum value **65**, and switches the count value of the first counter unit **60** from actual count value to the maximum value **65**. As a result, the radiation measurement apparatus **51** according to the second embodiment can prevent the output value output to the display unit **23** from becoming overflowed value, and therefore prevent the operator from faultily recognizing radioactivity.

Incidentally, in a case where the count value of the counter **61** reaches to the maximum value **65**, the radiation measurement apparatus **51** according to the second embodiment may be configured so as to set the maximum value **65** in the first counter unit **15**, and thereby display the maximum value **65** as count value in the display unit **23**.

FIG. **6** is a circuit configuration diagram of a radiation measurement apparatus **71** as another example of the second embodiment. Incidentally, the same reference numerals or characters in the radiation measurement apparatus **71** are assigned to the same or similar components and parts as those in the radiation measurement apparatus **51**, and the duplicated description thereof is omitted.

The first counter unit **72** includes a counter **61** and a comparison circuit **73**, as an overflow prevention device that prevents an overflow.

The comparison circuit **73** outputs a logic signal which is true to the counter **61** in the case where the count value of the counter **61** reaches to the maximum value **65**, and a logic signal which is false to the counter **61** in a case where the count value of the counter **61** is less than the maximum value **65**. The counter **61** outputs actual count value in a case where the logic signal output from the comparison circuit **73** is false, and the maximum value **65** which is set by the comparison circuit **73** in a case where the logic signal output from the comparison circuit **73** is true.

The radiation measurement apparatus **71** can achieve the effect of the radiation measurement apparatus **51** and omit the selector **63**. Therefore, a configuration of the radiation measurement apparatus **71** can be simplified.

Incidentally, in the second embodiment, the value which is compared with the counter **61** is not limited to the maximum value **65** and may be another value which is more than the maximum value **65**.

Third Embodiment

A third embodiment of a radiation measurement apparatus according to the present invention will be described with reference to the accompanying drawings.

FIG. 7 is a circuit configuration diagram of a radiation measurement apparatus **81** according to third embodiment.

The different point between the radiation measurement apparatus **81** according to the third embodiment and each of the radiation measurement apparatuses according to the first and second embodiments is that, for the sake of improving maintenance ease of the radiation measurement apparatus **81**, the radiation measurement apparatus **81** further includes a USB convertor **82**, a USB hub **83**, and a USB memory **84**. It is noted that the same reference numerals or characters in the radiation measurement apparatus **81** are assigned to the same or similar components and parts as those in the radiation measurement apparatus **1**, and the duplicated description thereof is omitted.

The radiation measurement apparatus **81** includes the radiation sensor **10**, the waveform shaping circuit **12**, the comparator **13**, a discrimination level setting unit **14**, and a first counter unit **15**, as a radiation measurement device. Further, the radiation measurement apparatus **81** includes the oscillator **16**, the AND circuit **17**, the second counter unit **18**, and the comparison circuit **19**, as a pile-up prevention device that prevents pile-up.

Furthermore, the radiation measurement apparatus **81** includes the USB convertor **82**, the USB hub **83**, and the USB memory **84**. The USB convertor **82** converts measurement data output from the selector **21** into serial data of USB standard and then outputs the serial data. The USB hub **83** as an output device connects the radiation measurement apparatus **81** with a data processing display unit **90**, and performs data transmission/reception and so on. The USB memory **84** as a memory device stores unique information of the radiation measurement apparatus **81** therein. The unique information is, for instance, information such as a calibration value of sensitivity of the radiation measurement apparatus **81** or the like, the production number of the radiation measurement apparatus **81**, usage and maintenance history, or the like.

The data processing display unit **90** connected with the radiation measurement apparatus **81** processes and displays measurement data of the radiation measurement apparatus **81**.

Next, an operation of the radiation measurement apparatus **81** according to the third embodiment will be explained.

The USB convertor **82** converts measurement data output from the selector **21** into serial data of USB standard and then outputs the serial data to the USB hub **83**. The serial data is transmitted to the data processing display unit **90** through the USB hub **83**. The data processing display unit **90** processes measurement data (the count values of the first and second counters **15** and **18**) output from the selector **21** and unique information of the radiation measurement apparatus **81**, stored in the USB memory **84** by performing required data procedure.

The data processing display unit **90**, for example, reads out the sensitivity of the radiation sensor **10** from the USB memory **84** and calibrates the count number of the first counter unit **15** output from the selector **21** on the basis of the sensitivity of the radiation sensor **10**, being unique information of the radiation measurement apparatus **81**.

In the radiation measurement apparatus **81** according to the third embodiment, since the unique information of the radiation measurement apparatus **81** is stored in the USB memory **84**, the radiation measurement apparatus **81** can smoothly move to measurement mode based on the unique information even if it is necessary to replace the radiation measurement apparatus **81** or the data processing display unit **90** with another one due to breakdown of the radiation measurement apparatus **81** or the data processing display unit **90**.

For example, the radiation measurement apparatus **81** can calibrate the count value of the radiation sensor **10** based on the calibration value of the radiation measurement apparatus **81**, read out from the USB memory **84**, and therefore display the measurement data which is calibrated, in the data processing display unit **90**. Thus, even if it is necessary to replace instrument such as the radiation measurement apparatus **81**, the calibration thereof can be eliminated. If there is backup radiation measurement apparatus **81** or backup data processing display unit **90**, the operator can immediately use backup radiation measurement apparatus **81** or backup data processing display unit **90** after the operator replaces with it.

Further, even an operator that does not know calibration method of the radiation measurement apparatus **81**, if the operator only has to change the radiation measurement apparatus **81**, can use the radiation measurement apparatus **81** without needing cumbersome work.

The USB memory **84** as memory unit may be included in the radiation measurement apparatus **81** or the data processing display unit **90**.

Although some embodiments of the present invention are described, the above-described embodiments are presented as some examples. Accordingly, it is noted that the present invention is not limited to the above-described embodiments. Since the above-described embodiments which are new embodiments can be embodied in various forms other than the specific embodiments described above, various omissions, substitutions, and changes may be made without departing from the spirit and scope of the invention. These embodiments and modifications thereof are included within the sprit and scope of the invention and are included within the scope of the invention as disclosed in the claims and equivalents thereof.

REFERENCE NUMERALS

1, **41**, **51**, **71**, **81** - - - radiation measurement apparatus
10 - - - radiation sensor
12 - - - waveform shaping circuit
13 - - - comparator
14 - - - discrimination level setting unit
15, **60**, **72** - - - first counter unit
16 - - - oscillator
17 - - - AND circuit
18 - - - second counter unit
19, **42**, **62**, **73** - - - comparison circuit
20 - - - coefficient setting circuit
21, **63** - - - selector
22 - - - setting value
23 - - - display unit
61 - - - counter
65 - - - maximum value
82 - - - USB converter
83 - - - USB hub
84 - - - USB memory
90 - - - data processing display unit

The invention claimed is:

1. A radiation measurement apparatus comprising:

a sensor that generates a detection signal in case of detecting a radiation;

a first counter that counts the number of the detection signal;

an oscillator that generates a periodic signal with predetermined period;

an AND circuit that outputs a logical product obtained by operating an AND operation between the detection signal and the periodic signal;

a second counter that counts the number of a signal output from the AND circuit; and

a display control circuit that selects for display a count value of the first counter in a case where a count value of the second counter is less than a first predetermined value or a value which is different from the count value of the first counter in a case where the count value of the second counter is not less than the first predetermined value.

2. The radiation measurement apparatus according to claim **1**, wherein the display control circuit selects for display a value based on the count value of the second counter in the case where the count value of the second counter is not less than the first predetermined value.

3. The radiation measurement apparatus according to claim **2**, further comprising:

a comparison circuit that determines whether the count value of the second counter is not less than the first predetermined value, wherein

the display control circuit selects for display the count value of the second counter in the case where the count value of the second counter is not less than the first predetermined value.

4. The radiation measurement apparatus according to claim **1**, wherein the first counter sets a second predetermined value as the count value of the first counter, and wherein the display control circuit selects for display the count value of the first counter after being set at the second predetermined value, in the case where the count value of the second counter is not less than the first predetermined value.

5. The radiation measurement apparatus according to claim **4**, further comprising a comparison circuit that determines whether the count value of the second counter is not less than the first predetermined value, and newly sets the second predetermined value as the count value of the first counter when the value counted by the second counter is not less than the first predetermined value.

6. The radiation measurement apparatus according to claim **1**, wherein the display control circuit selects for display a third predetermined value which is preliminarily set in a case where the count value of the first counter reaches to maximum count value.

7. The radiation measurement apparatus according to claim **6**, the third predetermined value is a maximum value counted by the first counter.

8. The radiation measurement apparatus according to claim **6**, further comprising:

a comparison circuit that determines whether the count value of the first counter reaches a maximum value or not, wherein

the display control circuit selects for display the third predetermined value in the case where the count value of the first counter reaches to the maximum count value.

9. The radiation measurement apparatus according to claim **6**, further comprising a comparison circuit that determines whether the count value of the first counter reaches a maximum value or not, and sets the count value of the first counter at the third predetermined value in the case where the count value of the first counter reaches the maximum value.

10. The radiation measurement apparatus according to claim **1**, further comprising:

a memory that stores an unique information of the radiation measurement apparatus; and

an output unit that reads out the unique information stored in the memory, and outputs the count value of the first counter and the unique information to an external equipment.

11. A radiation measurement apparatus comprising:

a sensor that generates a detection signal in case of detecting a radiation;

a counter that counts the number of the detection signal; and

a display control circuit that selects for display an actual count value of the counter in a case where the actual count value of the counter is less than a maximum value of the counter or a predetermined value which is different from the actual count value of the counter in a case where the actual count value of the counter reaches the maximum value.

* * * * *